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IASET

EFFECT OF ADDING PLASTIC WASTELDPE (LOW DENSITY POLYETHYLENE) AND PET (POLYETHYLENE TEREPHTHALATE) ON THE BEHAVIOUR OF STABILITY MARSHALL CHARACTERISTICS OF ASPHALT CONCRETE MIXTURE

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ABSTRACT

The use of both LDPE and PET plastic waste as an additive to asphalt can increase the stability value for the mixture of Asphalt Concrete -Wearing Course (AC-WC). This research aims to determine how much influence conventional asphalt and each addition of plastic waste material, both homogeneity, and stability value, on the characteristics of the asphalt concrete mixture. In the addition of plastic waste, LDPE and PET are made varying from 0%; 0.25%; 0.50%; 0.75%; 1.00%; and 1.25%. This research was conducted at the Transportation and Highway Laboratory, Engineering Faculty, Tadulako University. The Optimum Asphalt Content (KAO) of the AC-WC mixture was measured using the Marshall method. Each Marshall test results on conventional asphalt and variations in the addition of LDPE and PET plastics to hot asphalt with the highest stability value for each KAO, LDPE variation of 0.50% namely 1783.690 kg at 30 minutes immersion and PET variation of 0.50% namely 1766.926 kg at 30 minutes immersion. The results of the maximum stability value are tested by SEM and EDS to ensure the homogeneity of a mixture of both LDPE and PET and conventional asphalt. The results of the SEM and EDS tests show that the mixture of asphalt and LDPE is more homogeneous than asphalt and PET.

KEYWORDS: *Stability, Asphalt and LDPE, Asphalt and PET, SEM, and EDS*

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1. INTRODUCTION

Preliminary

The manufacture of plastic materials is difficult to replace with other materials for various applications, especially in daily life ranging from food packaging, household appliances, children's toys, electronics to automotive components. This increase in the use of plastic materials has resulted in an increase in the production of plastic waste from year to year. As an illustration, plastic consumption in Indonesia reaches 10 kg per capita / year, so it can be predicted that this is the amount of plastic waste produced.

As we all know that plastic is very difficult to decompose in the soil, it takes years and this will cause its own problems in handling. Disposal in the Final Disposal Site (TPA) of waste is not a wise enough solution in managing this plastic waste. Therefore, to reduce plastic waste that pollutes the environment, it can be used as an additional material for road construction (M. Syamsiro, 2017).

The use and utilization of plastic waste at a low cost and can reduce the problem of environmental pollution due to the increasing disposal of plastic waste every year. Research will be carried out in the form of asphalt modification with the addition of LDPE or plastic bag waste materials and PET mineral plastic bottles in the asphalt mixture to find comparisons in modifications that are expected to increase the life of the road pavement plan.

Asphalt concrete is a type of flexible pavement layer which is a hot mixture of continuously graded aggregate with asphalt as a binder at a predetermined temperature, then spread and compacted to form an interlocking structure, and make a major contribution to the strength performance of asphalt concrete hard layers.

Silvia Sukirman.1999. Highway Flexible Pavement, Nova.

Laston (Asphalt Concrete Layer) is a hot mix asphalt pavement layer. According to specifications Bina Marga Asphalt concrete is divided into 3 (three) types of layers, namely:

- Laston Layer Worn (*Asphalt Concrete – Wearing Course* AC-WC).
- Laston Layer Between (*Asphalt Concrete – Binder Course* AC-BC).
- Laston Layer Foundation (*Asphalt Concrete – Base* AC-*Base*).

2. RESEARCH METHOD

2.1 Research Site

The research was conducted at the Transportation and Highway Laboratory, Faculty of Engineering, Tadulako University. In this study, the materials used in the study were as follows: Coarse and fine aggregates came from Ex Watusapu, Ulujadi District, Palu City, which were stocked to AMP PT. Sapta Unggul is produced from a stone crusher machine. Filler minerals come from the sands of the Palu River, Filler comes from Tonasa brand cement and rock ash comes from a by-product of PT. Sapta Unggul.

LDPE Plastic Waste is often called a plastic bag or also called a crewet bag which is taken from the Final Disposal Site (TPA) in Kawatuna Village, Palu City, which is usually a necessity for everyone in shopping both in markets and supermarkets in storing luggage. Plastic bag waste can be found everywhere, including the environment around us.

The method of collecting LDPE and PET plastic waste is very simple, only random collection is carried out at the final disposal site and sorted according to the needs of the use of the waste. The LDPE taken is a special plastic bag or often known as a fussy bag. Meanwhile, PET was taken in 600 ml mineral bottles. In taking samples to note are:

Image 1. Location of Aggregate Collection

Figure 1: Location of Aggregate Collection.

Figure 2: Location of LDPE Waste Collection.

Figure 3: PET Waste Collection Location.

- After the plastic waste samples are obtained, both LDPE and PET are washed first using detergent soap, the point is to remove the oil content or other substances that affect when mixed with asphalt
- After washing, the wastes are dried in the sun to remove the water attached to the plastic waste.
- Cut or cut LDPE and PET waste with a width of 1-2 cm to make it easier during the crushing process. After that the waste is ready to be processed to the crusher machine.

Figure 4: LDPE Plastic Waste Shredder.

Figure 5: LDPE Plastic Material before and After Grinding Process.

Figure 6: PET Plastic Waste Shredder.

Figure 7: PET Plastic Material before and after Grinding Process.

2.2 Mix Design AC-WC

The purpose of the mix design is to get an optimal mix of aggregate and asphalt so that the pavement with optimal quality is produced. The materials that will be used in this study were chosen in order to meet the specifications of the asphalt concrete mixture, namely the Asphalt Concrete-Wearing Course AC-WC.

Determination of the composition of the mixture between coarse aggregate, fine aggregate, and filler is intended to obtain a mixture composition that meets the gradation requirements so that a surface layer is obtained where the bonds between the aggregate grains are interlocking. The planning of the used asphalt concrete mix is based on the Marshall method. Through this method, the approximate amount of asphalt can be determined so that it can produce a good mixture composition between aggregate and asphalt according to the technical requirements of the specified road pavement. This method is carried out by trial and error and then compares the results with the required gradation and is based on the percentage of use of coarse aggregate and fine aggregate.

(Bina Marga 2020)

2.3 Determining the Number of Test Objects

The research was carried out in 2 stages, namely determining the estimated optimum asphalt content (PKAO) with several comparisons of conventional asphalt and modified asphalt using LDPE and PET added materials. With each stage as follows:

The first stage I: Determining the estimated optimum asphalt content (PKAO) using conventional asphalt is as follows:

Determine the optimum asphalt content (PKAO) by adding Low Density Polyethylene (LDPE) plastic waste or plastic bags.

Table 1: Matrix of Number of Samples Determining Asphalt Optimum Content (AOC) + LDPE Plastic

LDPE Plastic Grade	Asphalt Variations Sample				
0.25 %	3	3	3	3	3
0.50 %	3	3	3	3	3
0.75 %	3	3	3	3	3
1.00 %	3	3	3	3	3
1.25 %	3	3	3	3	3
Total	15	15	15	15	15

Determine the optimum asphalt content (PKAO) by adding plastic waste type Polyethylene Terephalate (PET) or bottled mineral bottles.

Table 2: Number of Samples for Determining AOC + PET Plastic

Kadar Plastic PET	Asphalt Variations Sample				
0.25 %	3	3	3	3	3
0.50 %	3	3	3	3	3
0.75 %	3	3	3	3	3
1.00 %	3	3	3	3	3
1.25 %	3	3	3	3	3
Total	15	15	15	15	15

Second stage II: After each AOC is obtained, the remaining material is made by soaking for 30 minutes and 24 hours.

Table 3: Remaining Marshall Test Amount (Asphalt + LDPE)

No.	Asphalt + LDPE	AOC (30 minutes)	AOC (24 minutes)
1.	Asphalt + 0.25	3	3
2.	Asphalt + 0.50	3	3
3.	Asphalt + 0.75	3	3
4.	Asphalt + 1.00	3	3
5.	Asphalt + 1.25	3	3

Table 4: Total Marshall Tests Remaining (Asphalt + PET)

No.	Asphalt + PET	AOC (30 Minutes)	AOC (24 Minutes)
1.	Asphalt + 0.25	3	3
2.	Asphalt + 0.50	3	3
3.	Asphalt + 0.75	3	3
4.	Asphalt + 1.00	3	3
5.	Asphalt + 1.25	3	3

2.4 Preparation of Asphalt Mixture

In principle, the asphalt mixture can be carried out in two stages, namely determining the proportion of aggregate and determining the optimum asphalt content. This step applies to all types of asphalt mixtures even though these mixtures contain different types of aggregate and asphalt.

The following describes the process of mixing and compacting the test object.

a. The mixing process is carried out as follows:

- Prepare the materials for each required test object, namely ±1200 gr aggregate.
- Heat the mixing pan along with the aggregate to about 28°C above the mixing temperature and stir until smooth. Meanwhile the asphalt is also heated separately at the mixing temperature in the asphalt pan.
- Pour as much asphalt as needed into the heated aggregate, and then stir quickly until the aggregate is evenly coated.

b.The compaction process is carried out as follows:

- Thoroughly clean the test specimen mould fixture and the face of the masher and heat it to a temperature of 150°C.
- Between the asphalt mixture and the base of the mould is placed a piece of filter paper or blotting paper that has been cut according to the size of the mould.
- Put the whole mixture into the mould and poke hard with a spatula 25 times (15 times around the edges and 10 times in the middle). Then flatten the surface of the mixture into a slightly convex shape and place the filter paper on top.

- Placing the mould on the compactor base, and then compacting it by pounding it 75 times on the top side. Then remove the top plate of the connecting neck and then turn over the mould containing the test object and reinstall the top plate and neck of the joint, after that the surface of the test object that has been turned over is compacted with the same number of impacts.
- After solidification, the base pieces are carefully removed, removed and placed on a smooth flat surface, left for about 24 hours at room temperature.

2.4 Determination of Mixture Composition by Trial Mix Method

By using the proportions that have been obtained from the design mix, both from the supply regulation of cold aggregates and hot aggregates, it is necessary to conduct a mixing experiment to determine the performance of AMP. What needs to be considered during the mixing process is the length of mixing time, and if the length of mixing time in the mixer increases, it will cause the degree of asphalt aging (oxidation) to increase. High mixing temperatures will increase the degree of hardening of the hard asphalt, so the mixture will be stiffer than the results of mixing in the laboratory with the same material. The degree of hardening of an asphalt mixture is quite diverse, depending on the composition and thickness of the asphalt film covering the aggregate grains and other factors.

The asphalt mixture from the mixing experiment was tested by the Marshall method in the laboratory and compared with the results obtained in the design mix. Some of the recommended results from the mixing experiment are one-time mixing capacity, mixing time, mixing temperature, asphalt coating, and mix homogeneity and ease of operation.

2.5 SEM (Scanning Electron Microscope) Testing

Scanning Electron Microscope (SEM) is a type of electron microscope that depicts specimens by scanning them using a high-energy beam of electrons in a raster pattern scan. The electrons interact with the atoms so that the specimen produces a signal that contains information about the specimen's surface topography, composition, and other characteristics such as electrical conductivity.

3. RESULTS AND DISCUSSION

3.1 Asphalt Inspection Result of PEN 60/70

The asphalt used in the AC-WC mixture is Pen 60/70 produced by Pertamina. To determine the quality of the asphalt to be used, a test is carried out according to the characteristic value of the asphalt material. The results of testing the characteristics of the asphalt are presented in Table.

Table 5: Test Results of Pen. 60/70 of Asphalt Material

No.	Test	Test result	Spek.	Unit	Info.
1.	Penetrasi (25°C, 5 det)	66,60	60 - 70	0,1 mm	Qualify
2	Specific gravity	1,02	≥ 1,0	-	Qualify
3	Softening Point	48,90	≥ 48	°C	Qualify
4	Daktilitas (25°C, 5 cm)	109,00	≥ 100	cm	Qualify
5.	Viskositas (135°C)	371,61	≥ 300	cst	Qualify
6.	Flash point	325,50	> 232	°C	Qualify
7.	Losing Weight	0,059	≤ 0,8	%	Qualify

3.2 Asphalt Mixture with LDPE Variations

Examination of the physical properties of LDPE (Low Density Polyethylene) asphalt was carried out as in the Pen 60/70 asphalt test. The LDPE used as a modification material is mineral water plastic bottle waste.

Table 6: Test Results of Modified Asphalt LDPE (Low Density Polyethylene)

No.	Test	Test Result					Spek	Unit
		0,25%	0,50%	0,75%	1,00%	1,25%		
1.	Penetration (25°C)	26,90	25,60	25,60	24,00	16,90	-	0,1 mm
2.	Specific gravity	1,10	0,91	1,09	0,93	1,02	-	-
3.	Softening Point	49,70	51,45	53,05	51,45	56,40	-	°C
4.	Ductility (25°C)	148,60	90,60	85,55	83,70	32,05	-	Cm
5.	Viscosity (135°C)	685,64	694,42	827,20	772	756,88	≥ 300	Cst
6.	Flash Point	325,50	326,50	327,50	327,50	328,00	≥ 230	°C
7.	Losing Weight	0,043	0,092	0,193	0,083	0,136	≤ 0,8	%

Testing the basic properties of LDPE (Low Density Polyethylene) asphalt is carried out with levels of 0.25%, 0.50%, 0.75%, 1.00% and 1.25% by weight of asphalt, to determine the extent to which the addition of LDPE affects the properties of asphalt, hard asphalt base and mix quality.

3.3. Asphalt Mixture with PET Variations

Examination of the physical properties of PET asphalt is carried out as in the Pen 60/70 asphalt test. PET used as a modification material is plastic bag waste. Testing of the basic properties of PET asphalt is carried out with levels of 0.25%, 0.50%, 0.75%, 1.00% and 1.25% of the asphalt weight, to determine the extent to which the addition of PET affects the basic properties of hard asphalt and quality. mix. The test results of the asphalt characteristics are presented in table.

Table 7: Test Results of Modified Asphalt PET (Low Density Polyethylene)

No.	Test	Test Result					Spek	Unit
		0,25%	0,50%	0,75%	1,00%	1,25%		
1.	Penetration (25°C)	23,00	22,90	22,50	21,80	19,60	-	0,1 mm
2.	Specific Gravity	1,03	2,06	4,34	2,40	2,73	-	-
3.	Softening Point	51,80	52,60	52,65	52,75	58,60	-	°C
4.	Ductility (25°C)	135,90	131,20	122,15	92,55	39,50	-	cm
5.	Viscosity (135°C)	985,97	736,22	1206,62	1121,23	2231	≥ 300	Cst
6.	Flash Point	326,50	327,50	328,50	329,50	330,00	≥ 230	°C
7.	Losing Weight	0,029	0,028	0,017	0,029	0,029	≤ 0,8	%

3.4 Trial Mix Aggregate

The following are the steps in determining each fraction, namely; 3/8", stone ash, and cement (filler), namely:

Table 8: Sieve Analysis of Aggregate3/4"Fraction

Saringan No.	Bukaan (mm)	Berat tertahan (gr)	Kumulatif tertahan (gr)	% Tertahan	% Lolos	Spek.
1	25.000	0.00	0.00	0.00	100.00	100
3/4"	19.000	0.00	0.00	0.00	100.00	100
1/2"	12.500	618.90	618.90	29.42	70.58	80 - 100
3/8"	9.500	785.10	1404.00	66.73	33.27	70 - 90
#4	4.750	515.85	1919.85	91.25	8.75	50 - 70
#8	2.360	104.70	2024.55	96.22	3.78	35 - 50
#30	0.600	24.55	2019.10	97.39	2.61	18 - 29
#50	0.300	4.30	2053.40	97.60	2.40	13 - 23
#100	0.150	11.70	2065.10	98.15	1.85	8 - 16
#200	0.075	11.95	2077.05	98.72	1.28	4 - 10
PAN	-	26.95	2104.00	100.00		

Figure 8: Aggregate ¾" Fraction Gradation.

Table 9: Sieve Analysis of Aggregate 3/8" Fraction

Saringan No.	Bukaan (mm)	Berat tertahan (gr)	Kumulatif tertahan (gr)	% Tertahan	% Lolos	Spek.
1	25.000	0.00	0.00	0.00	100.00	100
3/4"	19.000	0.00	0.00	0.00	100.00	100
1/2"	12.500	4.55	4.55	0.21	99.79	80 - 100
3/8"	9.500	2.55	7.10	0.32	99.68	70 - 90
#4	4.750	979.50	986.60	44.48	55.52	50 - 70
#8	2.360	873.85	1860.45	83.88	16.12	35 - 50
#30	0.600	246.45	2106.90	94.99	5.01	18 - 29
#50	0.300	18.85	2125.75	95.84	4.16	13 - 23
#100	0.150	29.40	2155.15	97.17	2.83	8 - 16
#200	0.075	20.10	2175.25	98.07	1.93	4 - 10
PAN		42.75	2218.00	100.00		

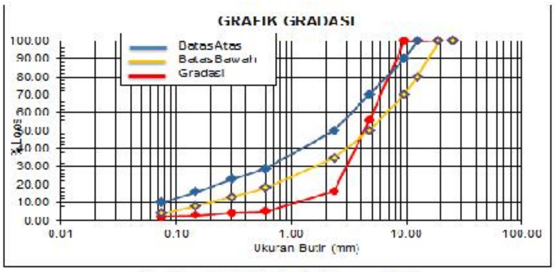

Figure 9: Aggregate 3/8" Fraction Gradation.

Table 10: Sieve Analysis of Sand Fraction

Saringan No.	Bukaan (mm)	Berat tertahan (gr)	Kumulatif tertahan (gr)	% Tertahan	% Lolos	Spek.
1	25.000	0.00	0.00	0.00	100.00	100
3/4"	19.000	0.00	0.00	0.00	100.00	100
1/2"	12.500	17.75	17.75	1.15	98.85	80 - 100
3/8"	9.500	19.50	37.25	2.42	97.58	70 - 90
#4	4.750	22.45	59.70	3.88	96.12	50 - 70
#8	2.360	67.95	127.65	8.30	91.70	35 - 50
#30	0.600	207.90	335.55	21.82	78.18	18 - 29
#50	0.300	456.90	792.45	51.52	48.48	13 - 23
#100	0.150	632.45	1424.90	92.64	7.36	8 - 16
#200	0.075	96.20	1521.10	98.89	1.11	4 - 10
PAN		17.00	1538.10	100.00		

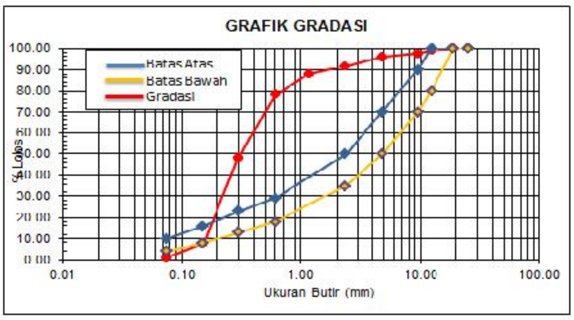

Figure 10: Sand Fraction Gradation.

Table 11: Sieve Analysis of Fly Ash Fraction

Saringan No.	Bukaan (mm)	Berat tertahan (gr)	Kumulatif tertahan (gr)	% Tertahan	% Lolos	Spek
1	25.000	0.00	0.00	0.00	100.00	100
3/4"	19.000	0.00	0.00	0.00	100.00	100
1/2"	12.500	0.00	0.00	0.00	100.00	80 - 100
3/8"	9.500	0.00	0.00	0.00	100.00	70 90
#4	4.750	0.00	0.00	0.00	100.00	50 - 70
#8	2.360	0.00	0.00	0.00	100.00	35 - 50
#30	0.600	0.00	0.00	0.00	100.00	10 - 29
#50	0.300	0.00	0.00	0.00	100.00	13 - 23
#100	0.150	0.55	0.55	0.16	99.84	8 - 16
#200	0.075	47.60	48.15	14.08	85.92	4 - 10
PAN		293.80	341.95	100.00		

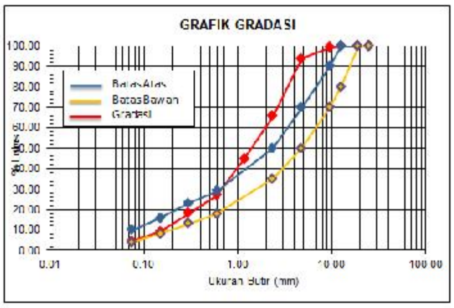

Figure 11. Fly Ash Fraction Gradation.

Table 12: Sieve Analysis of Filler Fraction

Saringan No.	Bukaan (mm)	Berat tertahan (gr)	Kumulatif tertahan (gr)	% Tertahan	% Lolos	Spek
1	25.000	0.00	0.00	0.00	100.00	100
3/4"	19.000	0.00	0.00	0.00	100.00	100
1/2"	12.500	3.30	3.30	0.16	99.84	80 - 100
3/8"	9.500	8.55	11.85	0.57	99.43	70 - 90
#4	4.750	112.25	124.10	5.97	94.03	50 - 70
#8	2.360	586.15	710.25	34.18	65.82	35 - 50
#30	0.600	371.85	1518.80	73.10	26.90	18 - 29
#50	0.300	180.45	1699.25	81.79	18.21	13 - 23
#100	0.150	187.35	1886.60	90.80	9.20	8 - 16
#200	0.075	97.35	1983.95	95.49	4.51	4 - 10
PAN		93.75	2077.70	100.00		

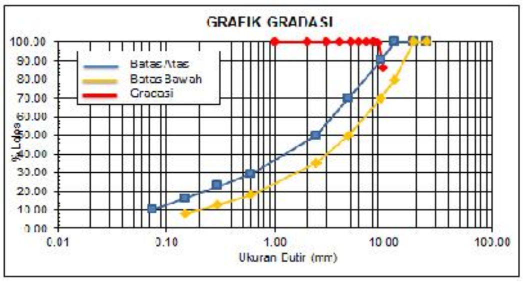

Figure 12. Fly Ash Fraction Gradation

From the results of the sieve analysis of the 4 (four) fractions, an aggregate composition is made to match the 2018 specifications

Table 13: Determination of the Aggregate Composition of the AC WC Mixture by Trial Mix Method

No. Saringan	Bukaan	Fraksi Agregat					Prosentase Setiap Fraksi					Total	Spck
		3/4 "	3/8 "	Abu Batu	Pasir	*Filler*	3/4 "	3/8 "	Abu Batu	Pasir	*Filler*		
		% Lolos					19%	23%	47%	9%	2%	100.00	
1 "	25.000	100.00	100.00	100.00	100.00	100.00	19.00	23.00	47.00	9.00	2.00	100.00	100
3/4"	19.000	100.00	100.00	100.00	100.00	100.00	19.00	23.00	47.00	9.00	2.00	100.00	100
1/2"	12.500	70.58	99.79	99.84	98.85	100.00	13.41	22.95	46.93	8.90	2.00	94.19	80 - 100
3/8"	9.500	33.27	99.68	99.43	97.58	100.00	6.32	22.93	46.73	8.78	2.00	86.76	70 - 90
#4	4.750	8.75	55.52	94.03	96.12	100.00	1.66	12.77	44.19	8.62	2.00	69.28	50 - 70
#8	2.360	3.78	16.12	65.82	91.70	100.00	0.72	3.71	30.93	8.25	2.00	45.61	35 50
#30	0.600	2.61	5.01	26.90	78.18	100.00	0.50	1.15	12.64	7.04	2.00	23.33	18 29
#50	0.300	2.40	4.16	18.21	48.48	100.00	0.46	0.96	8.56	4.36	2.00	16.34	13 23
#100	0.120	1.85	2.83	9.20	7.36	99.84	0.32	0.62	4.32	0.66	2.00	7.99	8 - 16
#200	0.075	1.28	1.93	4.51	1.11	85.92	0.59	0.44	2.12	0.10	1.72	4.97	4 10

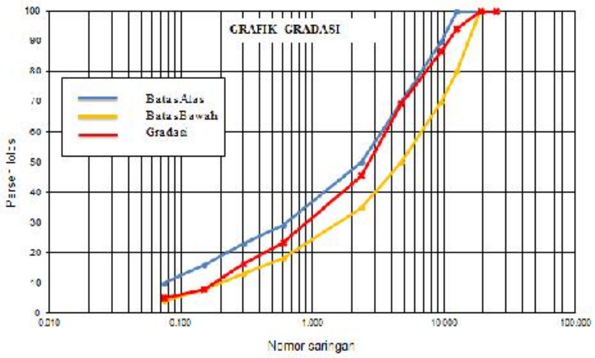

Figure 13: Combined Gradation by Trial Mix Method.

1). Determination of the Estimated AOC

FF = 4.64 %

CA= 100 % - (% Lolos No.8)

= 100 % - 45.10 %

= 54.90 %

FA = (% Lolos No.8) - % Filler

= 45.10 % - 4.64 %

= 40.46 %

C = Constants are taken1 (Constant value0.5 –

1.0 AC

Hence, Estimated AOC = 0.035 (% CA) + 0.045 (% FA) + 0.18 (% FF) + C

= 0.035 (54.90%) + 0.045 (40.46%) + 0.18

(8.00%) + 1

= 5.58% ≈ 6.00%

After obtaining AOC, it can be determined variations in asphalt content, namely by taking two values of asphalt content that are above and two values of content below with an increase of 0.5% for each value. Based on the above calculations obtained variations in asphalt content, namely:

5.0 %; 5.5 %; 6.0 %; 6.5 %; and 7 %.

The following is the calculation of the proportion of the AC-WC mixture for asphalt content5 %:

- Total test object weight= 1200 grams
- Asphalt weight : 1200 grams x 5% = 60 grams
- Aggregate weight : 1200 grams – 60 grams = 1140 grams

Mixed Aggregate Proportion

- Fraction ¾ ": 19% x 1140 = 216.6 grams
- Fraction 3/8": 23% x 1140 = 262.2 grams
- Fly Ash : 27% x 1140 = 307.8 grams
- Sand : 9 % x 1140 = 102.6 grams
- Cement (filler): 2% x 1140 = 22.8 grams

Aggregate Total = 1140 grams

3.5 Preparation of Test Objects in Determination of AOC

To obtain the AOC of AC-WC in this study used asphalt content from 5.0% to 7.0% with an increase in asphalt content of 0.5%. The AOC is the asphalt content that overlaps the hose that meets all the specifications of the parameters determined using the 2018 Bina Marga standard, where there are several parameters that must be met, namely Stability, Flow, Marshall Quotient (MQ), Cavity filled with asphalt. (VFB), voids in mixture (VIM), and voids in aggregate (VMA).

3.6 Asphalt Mixture Test Results Variations LDPE

In the modified LDPE, asphalt mixture, 5 different variations of the mixture are used based on the LDPE content, namely 0.25%, 0.50%, 0.75%, 1.00% and 1.25% of the total weight of the asphalt consists of 5 variations of asphalt content for each type of mixture while the analysis of the test results of the mixture is as follows.

3.6.1. Effect of Polymer Modified Asphalt Content on Stability Value

Table 14: Stability Value of Variations in LDPE Asphalt Content

LDPE Level (%)	Spek	Unit	Asphalt Content Variations (%)				
			5,00	5,50	6,00	6,50	7,00
0,25	> 1000	Kg	1354,53	1470,76	1597,56	1430,53	1417,12
0,50		Kg	1435,98	1515,75	1642,87	1578,41	1527,15
0,75		Kg	1394,76	1600,96	1524,41	1859,69	1588,95
1,00		Kg	1547,88	1685,62	1801,57	1703,22	1640,50
1,25		Kg	1060,97	1024,28	1593,70	1782,43	1750,44

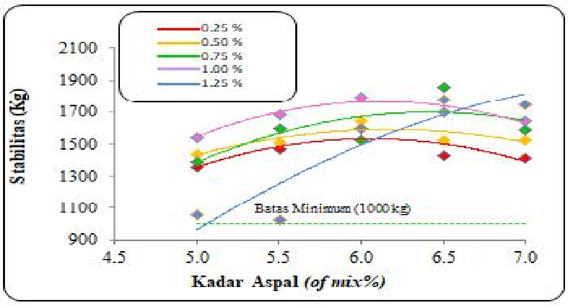

Figure 14: Relationship between Asphalt Content and Mixture Stability with LDPE 0.25% - 1.25%.

It can be seen based on the graph of the stability value of the estimated AOC test object presented in graphical form in Figure 12 that the stability of each variation of LDPE modified asphalt meets the required specifications, namely a minimum of 1000 Kg. However, it can be seen that the asphalt + LDPE content of 1.25% experienced a drastic decrease in the variation of asphalt from 5% to 5.5% and an increase in the variation of 7%.

3.7 Asphalt Mixture Test Results of Variations in PET Levels

In the modified PET asphalt mixture, 5 different variations of the mixture were used based on the PET content, namely 0.25%, 0.50%, 0.75%, 1.00% and 1.25% of the total weight of the asphalt consisting of 5 variations of the asphalt content. Asphalt for each type of mixture. The analysis of the test results of the mixture is as follows.

1. Effect of Polymer Modified Asphalt Content on Stability Value

Tabel 15: Stability Value of PET Asphalt Content Variation

PET Level (%)	Spec	unit	Asphalt Level (%)				
			5,00	5,50	6,00	6,50	7,00
0,25		Kg	1354,53	1498,98	1600,40	1500,01	1493,11
0,50		Kg	1139,95	1145,68	1535,58	1523,48	1495,49
0,75	>1000	Kg	1469,22	1522,17	1654,79	1612,70	1558,07
1,00		Kg	1247,52	1358,58	1615,49	1586,99	1508,76
1,25		Kg	1501,50	2141,18	1895,73	1908,86	1831,47

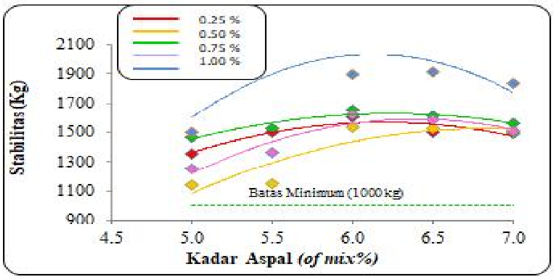

Figure 15.

CONCLUSION

Based on the results of research and data analysis, it can be concluded as follows:

- In general, for all LDPE grades in asphalt (except 1.25% grade), the use of mixed asphalt content from 5% to 7% meets the stability specification requirements, namely 1000 kg, which means all percentages of LDPE content added to asphalt can be applied.

- There is a tendency to increase the stability of the asphalt mixture with the increase in the LDPE content. For each LDPE content in asphalt, the stability value of the mixture will initially increase with the increase in asphalt content in the mixture to a certain asphalt content, and then decrease in line with the increase in asphalt content.
- For 3 levels of percentage addition of LDPE (0.25%, 0.50% and 1%) to the asphalt material, there is a tendency to increase stability since the asphalt content of 5%, 5.5% mixture and the highest peak of stability occurs at 6% asphalt content, and then decreased to 7% asphalt content. The trend of changes in stability values for the three levels of LDPE forms an inverted hyperbolic pattern, which means that if the asphalt mixture content increases after 6%, it will result in a decrease in stability or a decrease in load-bearing ability.
- The same pattern as number 3 above is also seen when the LDPE content in the asphalt is 0.75%, only the highest stability is detected when the asphalt content is 6.5%, and then decreases gradually as the asphalt mix content increases. The parabolic trend seen in the relationship between asphalt content and mixture stability tends to be more consistent with slow stability changes
- The highest stability of asphalt mixture for 3 types of LDPE content (0.25%, 0.50% and 1%) occurred at 6% asphalt mixture content (respectively; 1597.56 kg, 1642.87 kg, 1801.57 kg), while for 0.75% LDPE content stability occurs at 6.5% asphalt mixture content, which is 1859.69 kg.
- The five PET levels in the asphalt (from 0.25% to 1.25%) showed the same trend of changes in the stability of the asphalt mixture, which formed the best parabolic trend. In addition, the initial stability value will increase with the increase in the asphalt mixture content up to a certain level and then decrease along with the increase in the asphalt mixture content.
- The high and low levels of PET in the asphalt do not entirely affect the stability of the asphalt mixture that occurs. However, the highest stability was detected at 1.25% PET content in asphalt, while the lowest occurred at 0.25% PET content in asphalt.
- Except for 1.25% PET content in asphalt, the highest asphalt mixture stability for other PET levels occurs when the asphalt mixture content is 6%, which are 160.4 kg, 1535.58 kg, 1654, 79 kg and 1615 respectively. , 49 kg for each grade of PET in asphalt; 0.25%, 0.50%, 0.75% and 1%. For the PET content of 1.25%, the stability of the asphalt mixture was detected when the asphalt content was 6.5%, which was 1908.86 kg.

SUGGESTION

Based on the results of this study, several suggestions are proposed as follows:

- Further research is needed to add material for each variant in multiples of 1% in order to determine the stability value to be achieved.
- When the percentage of LDPE content in the asphalt reaches 1.25%, the change in the stability of the mixture looks inconsistent, where the change in the stability of the asphalt mixture no longer shows an inverted parabolic trend as happened with the lower LDPE content in asphalt. This means that the 1.25% LDPE content is not recommended to be used to increase the stability of asphalt mixtures.

- Except for 1.25% LDPE content, the percentage of LDPE addition to the asphalt material should be adjusted to the ADT conditions where the road construction will be used, including the prediction of its growth in the future.
- To determine the properties of the added material, it is necessary to test the melt to the maximum temperature limit so that the mixing temperature with asphalt can be known.
- In this study, the mixing method used the wet method, so comparisons could be made using the dry mixing method.
- The method of mechanically destroying LDPE plastic waste needs to change the dynamo using 3 (three) phases, so that the rotation system can be alternately bidirectional and accelerate the destruction of plastic waste.
- It is necessary to conduct research on the use of PEN 90/100 asphalt materials with the addition of using more plastic waste and being environmentally friendly.

REFERENCES

1. *Antarikso Utomo, R. (2008), Studi Komparasi Pengaruh Gradasi Gabungan di Laboratorium dan Gradasi Hot Bin Asphalt Mixing Plant Campuran LASTON (AC-Wearing Course) Terhadap Karakteristik Uji Marshall. Google, Title Time: 7/27/2019, 8.09 AM.*
2. *Arianti, Nasrul, Balaka, R, (2015), Analisis Pengaruh Penggunaan Polyethylene Terephalate (Pet) Terhadap Karakteristik Marshall Sebagai Bahan Tambah Pada Campuran Laston AC-BC. Google, Title Time: 2/25/2019, 5.49 AM.*
3. *Eliza Purnamasari, P, Suryaman, F, 2010 Pengaruh Penggunaan Botol Plastic Sebagai Bahan Tambah Terhadap Karakteristik Lapis Aspal Beton (LASTON) Google, Title Time: 10/9/2020, 5.44 AM.*
4. *Fitri, S, Sofyan M. Saleh, Isya, M, (2018), Pengaruh Penambahan Limbah Plastic Kresek Sebagai Subsitusi Aspal Pen 60/70 Terhadap Karakteristik Campuran Laston AC – BC. Google, Title Time: 1/29/2019 11:03 PM.*
5. *Hartono Sitorus, F, (2018), Pemanfaatan Limbah Plastic Sebagai Bahan Tambah Campuran Aspal Pada Pekerasan Jalan AC-WC Terhadap Nilai Marshall. Google, Title Time: 1/29/2019 10:54 PM.*
6. *Louis Christian Lagonda O. H. Kaseke, S.V. Pandey, (2017), Kajian Hubungan Batasan Kriteria Marshall Quotient Dengan Ratio Partikel Lolos Saringan No.#200-Bitumen Efektif Pada Campuran Jenis LASTON. Google, Title Time: 7/27/2019: 9.04 AM.*
7. *Modul I, 2017, Bahan Campuran Beraspal. Google, Title Time: 10/31/2020 8:01 AM.*
8. *Noor Tajudin, A dan Budi Suparma, L (2017), Analisis Indeks Stabilitas Sisa Pada Campuran Asphalt Concrete Dengan Penggunaan Limbah Plastic Sebagai Agregat Pengganti. Google, Title Time: 1/29/2019: 11.05 PM.*
9. *Nurminah, M., 2002, Penelitian Sifat Berbagai Bahan Kemasan Plastic dan Kertasserta Pengaruhnyaterhadap Bahan yang Dikemas, Fakultas Pertanian, Jurusanteknologi Pangan, Universitas Sumatera Utara, http://library.usu.ac.id/download/fp/fp-mimi.pdf Google, Title Time: 9/6/2019 7:35 AM.*
10. *Putra Ramadhan, R, (2017), Pengaruh Penambahan Limbah Plastic (Pet) Terhadap Karakteristik Marshall Dan Permeabilitas Pada Aspal Berpori. Google, Title Time: 1/29/2019 10:59 PM.*

11. *Rahmawati, A, (2015), Pengaruh Penggunaan Plastic Polyethylene (Pet) Dan High Density Polyethylene (HDPE) Pada Campuran Laston-WC Terhadap Karakteristik Marshall. . Google, Title Time: 1/29/2019 11:09 PM.*
12. *Sukirman, S, (1999), Buku Perkerasan Lentur Jalan Raya, Penerbit NOVA.*
13. *Sukirman, S, (2003), Buku Beton Aspal Campuran Panas. Penerbit Yayasan Obor Indonesia.*
14. *Tjitjik Wasiah Suroso, (2008), Pengaruh Penambahan Plastic LDPE (Low Density Poly Ethilen) Cara Basah Dan Cara Kering Terhadap Kinerja Campuran Beraspal. Google, Title Time: 2/25/2019: 5.57 AM.*
15. *Rizky Puspitasari, T. Wibisono, G, Malik, A, (2018), Pengaruh Penambahan Limbah Botol Plastic Terhadap Karakteristik Marshall Pada Beton Aspal Lapis Pengikat. Google, Title Time: 1/30/2019 2:59 PM.*
16. *Wantoro, W, Kusuma, N, Hario Setiadji, B, Kusharjoko, W,. (2013), Penambahan Plastic Bekas Tipe Low Density Polyethylene (LDPE) Terhadap Campuran Kinerja Beraspal. Google, Title Time: 30/1/2019 2:47 PM.*
17. *Pusat Penelitian dan Pengembangan Jalan dan Jembatan, 2007, Google, Title Time: 1/29/2019 11:33 PM*
18. *Badan Penelitian dan Pengembangan Pusat Litbang Jalan dan Jembatan, 2007, Modul Pengujian Laboratorium Pekerjaan Campuran Beraspal Pana. Departemen Pekerjaan Umum*
19. *SNI 06-2489-199, Metode Pengujian Campuran Aspal Dengan Alat Marshall.*
20. *Direktorat Jenderal Bina Marga. 2018. Spesifikasi Umum Revisi 2. Divisi 6 Seksi 6.3 Campuran Beraspal Panas, Kementerian Pekerjaan Umum dan Perumahan Rakyat*
21. *Kementerian Pekerjaan Umum dan Perumahan Rakyat Direktorat Jeneral Bina Marga. 2020. Penentuan Komposisidari Fraksi Agregat Untuk Gradasi Campuran AC-WC (Asphalt Concrete-Wearing Corse) dengan Aplikasi Microsoft Excel. https://binamarga.pu.go.id Google, Title Time: 5/10/2020 19:20 PM.*
22. *Tokoplas.com. 2020. Jenis Plastic LDPE (low density polyethylene). https://tokoplas.com/news/jenis-plastik-ldpe-low-density-polyethylene/Google, Title Time: 5/10/2020 20:15 PM.*
23. *Tokoplas.com. 2020. Jenis Plastic LDPE (low density polyethylene).*
24. *https://tokoplas.com/news/fakta-tentang-ldpe/ Google, Title Time: 5/10/2020 21:25 PM.*
25. *Audia Wira Rachmadi. 2018. Plastik, Manusia dan Lingkungan. Si jagonya Kemasan Plastik (PET), Surabaya, https://warstek.com/2018/02/14/pet/ Google, Title Time: 6/10/2020 22:30 PM.*
26. *Kitasipil.com Bihitz Toeflkita. Banda Aceh. https://www.kitasipil.com/2017/04/mengenal-bahan-addictive-anti.htmlSeptember 2017, Google, Title Time: 6/10/2020 22:45 PM.*
27. *Mandeleyev Rapuan Biantong, Makassar, Sulawesi Selatan SEM (Scanning Electron Microscope).http://mandeleyev-rapuan.blogspot.com/2012/03/sem-scanning-electron-microscope.htmlMaret2012, Google, Title Time: 7/10/2020 23:40 PM.*